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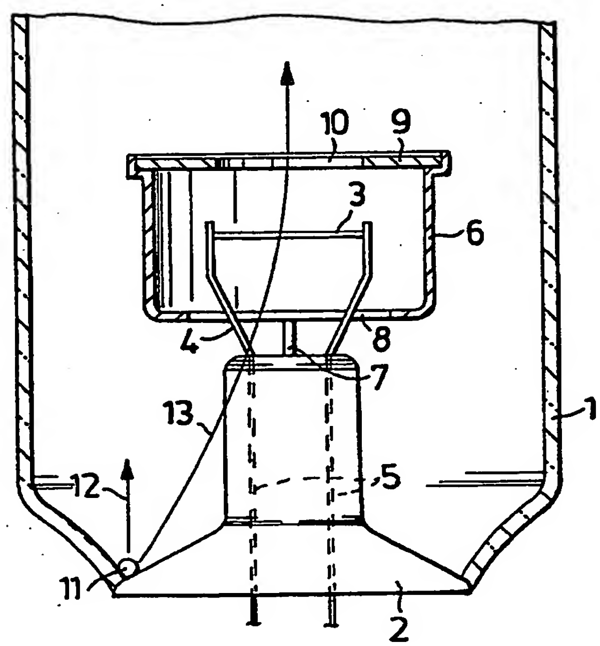
(54) Title: CATHODE UNIT FOR FLUORESCENT TUBE

(57) Abstract

Cathode unit intended for use in a fluorescent tube and designed in such a way that the service life of the tube is increased markedly as a result of a reduction in the loss of emmission material from the cathod (3). These material losses are caused by, inter alia, ion bombardment and by vaporization of the emission material. In order to achieve a marked increase in the reflection of released ions and molecules back to the cathod surface, both ions and molecules which have been released through ion bombardment and ions and molecules which have been vaporized from the cathod surface, the cathode (3) is surrounded by an electrically conductive cathode shield (6) in the form of a box-shaped casing which is, however, electrically insulated from the cathod. An opening (8) is made in the bottom of the shield for inserting the cathod (3). The open end of the shield (6) is sealed by means of a disc (9), preferably made of mica and provided with a centrally located hole (19). The hole diameter of the mica disc (9) should be selected so that it is as small as possible while bearing in mind the fact that the starting voltage for the tube should not exceed a predetermined value. The opening (8) in the bottom of the shield (6) should be of at least the same area as the hole in the mica disc (9).



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CATHODE UNIT FOR FLUORESCENT TUBE

The present invention refers to a cathode unit for fluorescent tubes with a cathode which is permanently mounted in relation to the tube wall and which is surrounded by a cathode shield which consists of electrically conductive material and which is not connected electrically to the cathode.

The service life for a fluorescent tube counted in hours of burning time is mainly determined by the service life of the tube cathodes. When the cathodes have lost a certain portion of their emission material consisting of alkaline earth oxides, their electron emitting capacity has dropped to such an extent that the tube will either not start or will enter a flickering stage which rapidly pulverizes the remaining emission material.

It is well known that surplus barium dissolved in the mixed crystals of the emission material make the alkaline earth oxides semiconductive and reduce the liberation work of the electrons. This surplus barium is formed through a chemical reaction between barium oxide and tungsten in accordance with the following formula.

$$6\ BaO + W \rightarrow Ba_3WO_6 + 3\ Ba$$

The barium tungstate thus formed remains as an intermediate layer between the tungsten and the actual emission substance throughout the service life of the cathodes while the barium is continuously diffused as vapour through the substance.

The barium tungstate layer entails a damping of the reaction according to the above formula, i.e. a reduced formation of barium. As a result

of this, all of the barium will not have been vaporized until after about 30 000 hours of continuous burning of a normal fluorescent tube. The stresses on the tube cathodes during the start process are, however, so large that the service life is reduced by a factor of 2-3 during the normal use of a fluorescent tube, i.e. with a mean connection period of 2-3 hours a time.

Loss of the cathode material which serves as emission substances and the concomitant reduction in the service life of the fluorescent tube are caused, in principle, by three different processes, namely 1) removal of emission material due to ion bombardment, particularly in conjunction with insufficient cathode temperatures; 2) vaporization of emission material; and 3) chemical reactions between the emission material and gaseous impurities in the tube.

In the design of a fluorescent tube intended for an extremely long service life during which the tube will be ignited and extinguished a considerable number of times, the tube cathodes must be designed in such a way that these three reasons for reduced cathode service life are taken fully into account.

A prerequisite for the removal of emission material due to ion bombardment is, in principle, that each atom which leaves the cathode surface never returns to the cathode. This is, however, only true in a vacuum. In reality the cathode is surrounded in a normal fluorescent tube construction by a rare gas atmosphere with a pressure of about $2.5\ 10^2$ Pa. Consequently, the free medium length of movement for the ions and molecules released from the surface is considerably shorter than the distance between the cathode and the tube wall. As a result, many of the released ions and molecules are reflected back and fall in towards the cathode surface. This considerably reduces the material loss. Such a reduction is, however, insufficient in the case of cathodes for long-life tubes.

The vaporization of the emission substance is comparatively constant during continuous operation but takes place more rapidly after each start and in the minutes following a start due to the increased cathode temperature. This means that a cathode for a long-life tube must be designed so that vaporized ions and molecules are reflected back to the cathode surface to a considerable extent and so that the cathode temperature remains moderate during the actual start period.

The purpose of the present invention is to solve the problems outlined above and thus to achieve a cathode design which is inteded for use in a fluorescent tube and which markedly increases the service life of the tube.

According to the invention, this is achieved through the cathode shield, consisting of a box-shaped casing, the bottom of which has an opening permitting the cathode to be inserted into the interior of the box, and through sealing the end of the box with a disc provided with a centrally located hole and made of electrically insulating material. A cathode unit of this type means that ions and molecules which have been released from a cathode surface through ion bombardment and ions and molecules which have been vaporized from the cathode surface are reflected back to the cathode surface to a far greater extent.

The cathode shield should preferably consist of iron or nickel. The disc, which must consist of a material which is not pulverized during the ion bombardment, can consist to advantage of mica.
The hole in the disc must have as small diameter as possible so as to reduce the blackening of the inside of the tube wall to a minimum. Too small a hole diameter will, however, mean that the starting voltage of the fluorescent tube will rise in undesirable manner. Consequently, the hole in the disc should have a diameter which is as small as possible while bearing in mind the fact that the starting voltage of the tube may not exceed a predetermined value. The most suitable hole diameter for a normal fluorescent tube with a tube diameter of 38 mm has proved to be 10-12 mm.

Since undesirable chemical reactions between the emission material and gaseous impurities in the tube can be disastrous for the service life of the tube, it is of the greatest importance that an efficient pump process be used when manufacturing the tube to remove all traces of different gases. Experience has shown that the most efficient pump process is achieved in an automatic pump unit where vacuum pumping under high temperature is combined with "internal pumping" achieved by feeding mercury drops into the hot fluorescent tube. When the mercury drops strike the fluorescent tube they are vaporized explosively and give rise to a diffusion pump effect in the fluorescent tube. This entails an extremely efficient removal of impurities. If this is to take place to a sufficient extent it is, however, essential that the cathode does not exercise any restrictive effect on the efficiency

on the abovementioned pump process. For this reason the opening in the bottom of the cathode shield should preferably have an area which is at least equal in size to the area of the hole in the disc.

The invention is described in further detail below in the form of a design example and with references to the appended drawings. Fig. 1 shows one end of a fluorescent tube provided with a cathode unit designed and constructed in accordance with the invention. Figs. 2a and 2b show - in a vertical cross section and in a view from beneath respectively - a cathode shield used for the cathode unit. Fig. 3 shows, in plan, a mica disc intended to cover the open end of the cathode shield illustrated in Fig. 2a and Fig. 2b. Fig. 4 is a chart which illustrates the dependency of the starting voltage and the degree of blackening on the hole diameter of the mica disc.

Fig. 1 shows, in section, one end of a fluorescent tube designed and constructed in accordance with the invention. The glass wall (1) of the tube is sealed by a foot (2) at one end in the conventional manner. This foot serves simultaneously as a base for the cathode supports (4) which support the tube cathode (3). These cathode supports, which are electrically conductive, are connected by means of supply wires (5) fused into the foot (2) through which current can be made to pass through the cathode (3) and heat up the cathode. The cathode (3) is surrounded by a cathode shield (6) which should preferably be of iron or nickel. The shield (6) is supported by a brace (7) fused into the foot (2) and is electrically insulated from the cathode (3).

As can be seen most clearly from Figs. 2a and 2b, the cathode shield (6) is shaped like a box, in the bottom of which an oblong opening (8) has been made for inserting the cathode (3) and parts of the cathode supports (4). The open end of the cathode shield (6) is sealed with the aid of a mica disc (9), the thickness of which should preferably amount to 0.10 - 1.15 mm. As can be seen from fig. 3, the mica disc (9) is provided with a centrally located hole (10), preferably circular in shape. The hole (10) has a diameter of 10-12 mm for a normal fluorescent tube with a tube diameter of 38 mm. A smaller diameter than this will, admittedly, reduce the blackening of the inside of the tube wall but will, simultaneously, increase the starting voltage to unacceptable values, as is illustrated in fig. 4, which shows the starting voltage U in volts as well as the relative degree of blackening S as a function of the dia-

meter D_{10} in mm of the hole (1). A larger hole diameter will reduce the starting voltage no more than insignificantly but will increase the blackening of the tube wall considerably.

It is important that the disc (9) be of mica or some other electrically non-conductive material which does not emit a gas since the ion bombardment would, if the disc were made, for example, of iron, give rise to further pulverized material and thus increase the blackening of the tube wall.

The design described above offers a further advantage, namely during the half periods when the spiral (3) acts as an anode. Since the discharge must pass through the mica disc (9) provided with a hole, a marked increase will be obtained in the electron density adjacent to the spiral (3) which functions as an anode. The anode drop will thus be reduced. This will entail a reduction in the cathode temperature and thus reduce the rate of vaporization.

As has been mentioned earlier, it is desirable that the tube be evacuated by means of a pump process in which vacuum pumping is combined with "internal pumping" achieved by permitting mercury drops to strike the hot tube. A drop of this type is illustrated schematically at (11) in fig. 1. When the drop strikes the heated fluorescent tube (wall (1) and/or foot (2)) it is vaporized explosively and the mercury vapour thus formed will rapidly flow out. The arrows (12 and 13) indicate in a schematic manner the most important flow paths taken by the vapour. The mercury vapour which follows the path marked by the arrow (13) must not be obstructed by the construction formed from the cathode shield (6) and the mica disc (9) if the carbon dioxide which exists at the emission layer and which was formed through conversion from carbonates to oxides is to be removed efficiently and if the internal pumping is to be effective. For this reason the hole diameter in the mica disc (9) should exceed 10 mm (for a fluorescent tube with a tube diameter of 38 mm) and the bottom opening (8) in the cathode shield (6) must have an area which is at least as large as the hole area of the mica disc but preferably larger.

The cathode design described above makes it possible, while retaining a normal burning time of 3 hours per connection, to achieve a service life which is 3-4 times longer than that of conventional fluorescent tubes.

Claims

1. A cathode unit for fluorescent tubes with a cathode (3) permanently mounted in relation to the tube wall (1) and surrounded by a cathode shield (6) which is not electrically connected to the cathode and which consists of electrically conductive material, c h a r a c - t e r i z e d by the fact that the cathode shield (6) consists of a box-shaped casing, in the bottom of which an opening (8) is made and that the open end of the box is sealed by means of a disc (9) provided with a centrally located hole (10) and made of electrically insulating material, said hole (10) having a diameter which is selected so that it is as small as possible, while still bearing in mind the fact that the starting voltage for the tube may not exceed a pre-determined value, and that the opening in the bottom of the cathode shield (6) has an area which is at least as large as the area of the hole in the disc (9).

2. A cathode unit in accordance with claim 1, c h a r a c t e r i z e d by the fact that the diameter of the hole (10) in the sealing disc (9) is 10–12 mm.

3. A cathode unit in accordance with claim 1 or 2, c h a r a c t e - r i z e d by the fact that the cathode shield (6) consists of iron or nickel.

4. A cathode unit in accordance with any preceeding claim, c h a r a c - t e r i z e d by the fact that the disc consists of mica.

Fig.1

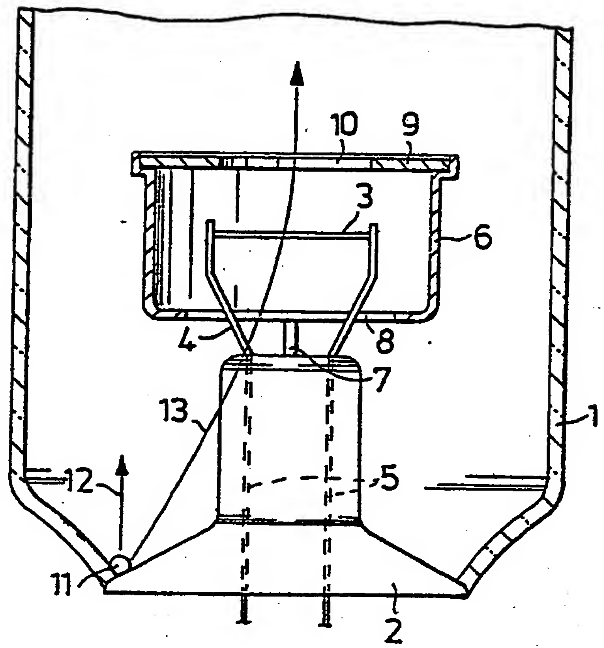


Fig.2a

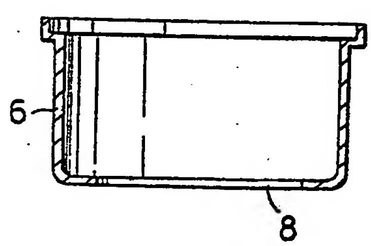


Fig.2b

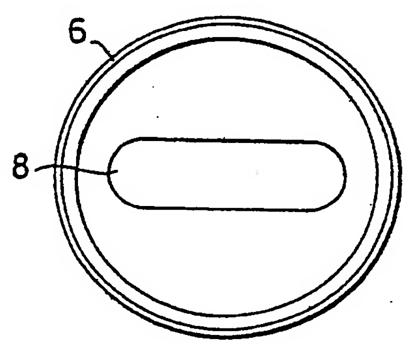


Fig. 3

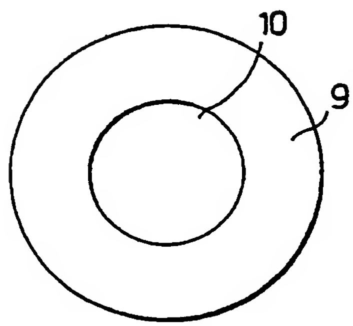
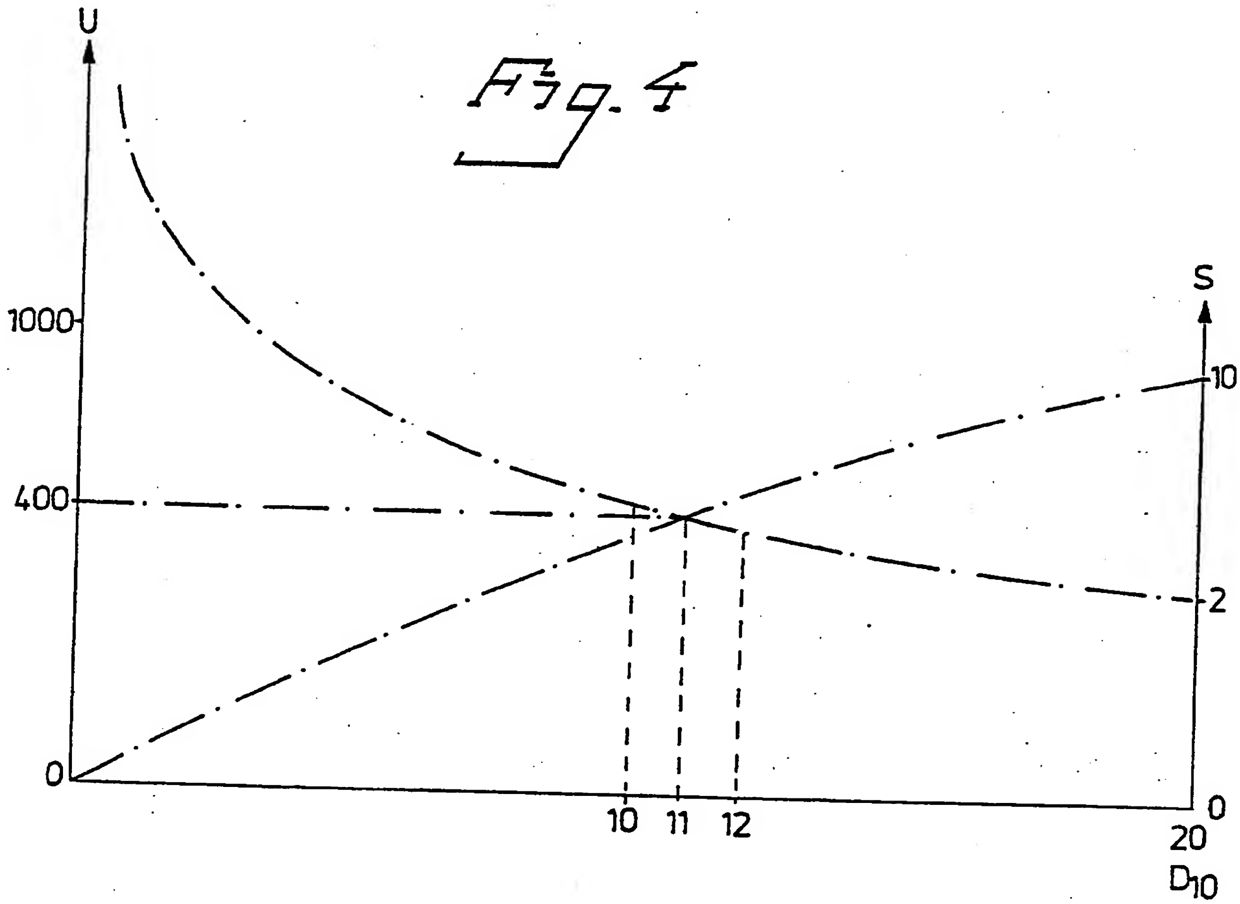


Fig. 4



INTERNATIONAL SEARCH REPORT

International Application No PCT/SE80/00279

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC 3

H 01 J 61/04, H 01 J 61/26

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC 3	H 01 J 61/00, 02, 04, 09, 10, 26
National Cl	21f:82/01, 06
US Cl	313/204-209

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
A	SE, B, 338 268 published 1971, September 6, Philips*	1, 3, 4
A	GB, A, 1 133 240 published 1968, November 13, Philips*	1, 3, 4
A	SE, B, 343 429 published 1972, March 6, Perkin Elmer Corp**	1
A	GB, A, 1 183 114 published 1970, March 4, Perkin Elmer Corp**	1
A	SE, C, 213 249 published 1967, May 30, Philips***	1, 3
A	GB, A, 841 343 published 1960, July 13, Philips***	1, 3
A	DE, C, 955 341 published 1956, December 13, Physikalisch-Teknische Werkstätten Dr Ing Walter Heimann	1
A	US, A, 2 238 277 published 1941, April 15, Miller	1
A	US, A, 2 917 650 published 1959, December 15, De Caumont	1
A	US, A, 3 121 184 published 1964, February 11, Fox	1, 3
A	US, A, 2 725 497 published 1951, April 25, Mason	-
A	GB, A, 1 219 705 published 1971, January 20, Hitachi Ltd	1, 3, 4

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IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
1981-02-04	1981-02-12
International Searching Authority [1]	**Signature of Authorized Officer** [20]
Swedish Patent Office	Anders Axberger

International Application No. PCT/[illegible]0/00279

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

III Documents considered to be relevant (cont)

*, **, *** refers to the same patent family

V.☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1.☐ Claim numbers ________, because they relate to subject matter [12] not required to be searched by this Authority, namely:

2.☐ Claim numbers ________, because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

VI.☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this international application as follows:

1.☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2.☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3.☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.